JOINING THE CONVERSATION: Scaffolding and Tutoring Mathematics

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Abstract

Tutoring is one of those skills which require the ability to communicate an in-depth understanding of the subject. This article is about scaffolding while tutoring, and the tutoring talents described can be applied across the curriculum. Lev Vygotsky's ideas about communication and education play a key role in the development of scaffolding strategies in tutorial or small group study sessions. These ideas can be used by a tutor/facilitator to help a student learn specific content at the most basic and immediate level of that student's academic need so it can be applied in a much broader context. The point of scaffolding strategy is to help tutors and facilitators engage students in the learning process.

At conferences, one often hears that "conventional wisdom" informs us that tutors should not put a pen or a pencil on a student's work—should not do the work for the student in any way, shape, or form. This wisdom assumes the position that doing the work for a student is not conducive to the development of good learning strategies. In many ways, this is correct. Doing the work for a student will not enhance learning if the work that is done by the tutor is the only work being done. However, if the work completed by the tutor is part of a scaffolding strategy that will engage the student, bring a better understanding of the materials, and lead to the student's ability to independently do the work, then the assistance serves a good purpose, and conventional wisdom is, if not incorrect, then in need of some revision. The key strategy for any assistance a tutor may offer is to keep the student engaged throughout the exercise while gently prodding for possible solutions through dialogue and by provoking problem-solving behaviors.

Background

Scaffolding, a term coined by Jerome Bruner (1960) and described in detail below, is the technique that a tutor/facilitator might use to help a student to learn specific content. Scaffolding is a support strategy—a way to work closely with a student at the level s/he requires for the best possible

learning outcome. Tutorial scaffolding acts just like the support structures one would see along the side of a building that construction workers use while completing various tasks. Once those tasks are completed, the scaffolding is removed. A tutor may use scaffolding to work with a student on difficult aspects of content materials and then remove that additional support once the student can independently complete the task.

Of course, since there may be the occasional student who attempts to "play" the system and have the tutor do all of his or her work, it is especially important for the tutor to make certain the student does the majority of the work as independently as possible. The decision about who is and who is not trying to play the system rests with the tutor, so it is important that the tutor try to determine what each student understands about the content, what the student can contribute to the process, and how much s/he can accomplish independently. From the tutor's knowledge of the student's current understanding and ability and willingness to actively engage in the learning process, the proper scaffolding can be applied.

The approach to tutoring may vary widely from student to student depending on the level of preparedness, learning style, personality, and any number of other factors. First meetings with students present an opportunity to find out about students' academic support needs by determining their current understanding of the content of the course. Students who need quite a bit of tutorial support are often weak (or entirely lacking) in prerequisite background material and may have problems keeping up with the course material. Other students may require much less from a tutor and will show this by being able to converse freely about major course topics. The amount of scaffolding used during sessions will be determined by what the tutor decides about the student's abilities and current levels of understanding.

Vygotsky

Scaffolding is an outgrowth of Vygotsky's ideas that are of particular interest and value to academic support personnel searching for positive ways to help students learn. While Vygotsky's research focused on the learning and language development of children, certain aspects of his thought can be illuminating and useful in a tutorial setting in order to help adult students learn, as well. Scaffolding is a support strategy that may be employed in collaboration between a tutor and a student at whatever age or grade level that student might be.

Lev Vygotsky, a Russian psychologist and educator, viewed learning as an event where communication is both individual and social. Vygotsky (1929) says that educational development uses "the primary function of speech… communication, [and] social contact" (p. 8-9). The self-centered language children use to learn and share information is social in nature and necessary for transmitting information that raises the individual's ability to actively participate in his or her social environment. It is this ability to move from the egocentric speech where s/he "transfers social, collaborative forms of behavior to the sphere of inner-personal psychic functions" (p. 9) to a more social context that marks the educational development of the individual.

Language and Theory

Communication has an impact on the ability of a student to learn. The terminology or words that are used in all social and educational interactions play an important role in what the individual will accept as real and valid. Language allows humans to construct reality and to describe and define their experience. Language becomes a purposeful series of signs, symbols, numbers, letters, words, art, music, or graphic designs that can transform the merely personal into a social context. With language, people share experiences and go beyond the confines of immediate experience to include reflection about things and events that cannot be seen or felt at a specific moment in time. Without language to define and describe our environment, reality is limited to personal and immediate local experience. Social and cultural consciousness would be limited as would emotional and affective feelings such as empathy.
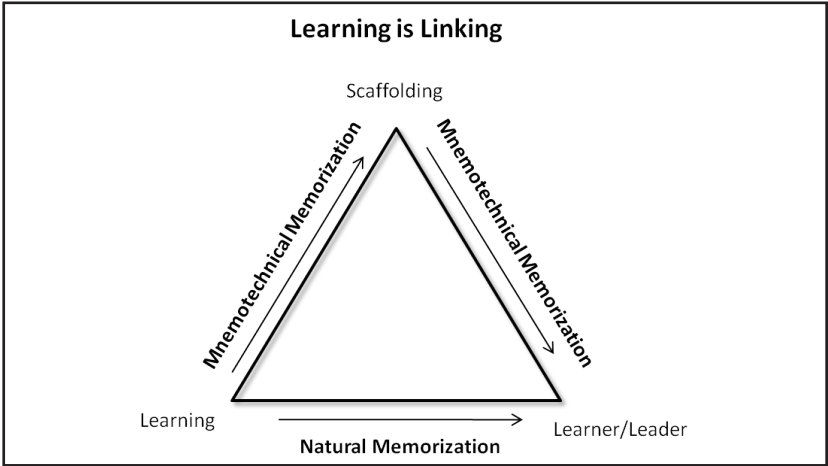
Vygotsky (1929) looks at a mnemotechnical method of memorizing, explained as "the method of memorizing by means of signs" (p. 1). This technique is used, Vygotsky tells us, by children as they learn language and, later, other social and educational tasks. That is, the signs indicate what has to be learned, and the student discovers how to memorize the connection between the sign and what s/he is expected to learn. As the child matures and begins to understand the social uses of language, s/he "with the help of the indicative function of words [. . .] begins to master his [her] attention, creating new structural centers in the perceived situation" (Vygotsky, 1978, p. 35). This technique may be considered in terms of two facets: natural and cultural mnemonics. The distinction may be described as an applied pedagogical usage of Ivan Pavlov's (Nobel 1904) ideas about association and conditioned reflex:

> The relation between the two forms can be graphically expressed by means of a triangle: in case of natural memorization a direct associative or conditional reflexive connection is set up between two points, A and B. In case of mnemotechnical memorization, utilizing some sign, instead of one associative connection AB, the others are set up AX and BX, which bring us to the same result, but in a roundabout way. Each of these connections AX and BX is the same kind of conditional-reflexive process of connection as AB. (Vygotsky, 1929, p. 5)

The "cultural" aspects of mnemonics in learning are inherent in teaching/learning situations in which the student participates at the direction of others; the "natural" aspects are those learning behaviors which are inherent with each individual. The social and individual are seen in a dynamic and symbiotic relationship during the learning process as the learner uses associations between and among signs to memorize information. The language of mathematics can be seen to fall under this rubric.

The agent that facilitates this memorization and learning may be, for our purposes, the teacher or the tutor. When scaffolding is used, the direct application of information to a given task will begin the associative process by using exactly those collaborative behaviors that seem to have a positive

impact on the child's ability to learn. Valkenburg & Dzubak (2009) point out that linking something new and/or difficult to something already known is intentional or purposeful learning. The collaborative model of scaffolding may offer a comfortable environment for establishing those links.

Learning is Linking

Scaffolding

Mnemotechnical Memorization

Mnemotechnical Memorization

Learning

Natural Memorization

Learner/Leader

Figure 1. Schematic of Vygotsky's natural and mnemotechnical method of memorizing.

Often, students have difficulty learning the technical jargon for a class. It is very important that they learn such terminology, but it is just as important to remember that many do not arrive in class predisposed to learning that terminology. An association has to be intentionally made. During a tutoring session, whether using scaffolding or not, tutors should translate material into language that students can understand, followed by a restatement of the same material in more technical terms. This technique is relevant to Vygotsky's concept of mnemotechnical learning because understanding the proper terminology will follow the association and connection from the less complex to the more complex. That is one role of the tutor—helping the student move from one level of understanding to the next.

According to Vygotsky (1934a), a child goes through levels of learning or cultural development, starting with internalizing signs from the environment to the application of those signs in given situations. The process is one of change from naive psychology to cultural or mature understanding. In language development, children learn the meanings of words through the continued interaction with the people around them. They go from vague understanding to mastery. Progress from dependent to independent cognitive thought can be seen in this process of language development and in the way children solve problems.

Language, therefore, allows the shift between subjective and objective interaction and thought. It, language, allows one to create new contexts (formats) for a wide variety of things and ideas. This change of format is

important because it implies a change in the cognitive perspective of the individual and is a subtle movement from inner to social or social to inner understanding. Vygotsky described this change in the shift from oral to written narratives:

> Inner speech is condensed, abbreviated speech. Written speech [is] deployed to its fullest extent, more complete than oral speech. Inner speech is almost entirely predicative because the situation, the subject of thought, is always known to the thinker. Written speech, on the contrary, must explain the situation fully in order to be intelligible. The change from maximally compact inner speech to maximally detailed written speech requires what might be called deliberate semantics - deliberate structuring of the web of meaning. (Vygotsky, 1934b, p. 2)

It is the responsibility of the culture and, therefore, the teacher, to find suitable ways to teach. The construction of cultural perspective should be guided by using techniques that will enhance the student's ability to learn. The onus of responsibility for developing a learner-friendly style of pedagogical communication rests, Vygotsky says, squarely with those who would transmit information.

Not all aspects of this particular argument ring true; socio/cultural norms can have a tremendous impact on the ability of a student to learn. The tutor or teacher should bear the responsibility of developing a clear style of presentation and communication. Yet, there should be some personal ownership of the learning process, some responsibility for learning that rests with the individual student. Solon, referred to as the law-giver of ancient Greece, proposed that one must know oneself. In Plato's *Apology*, Socrates offers the idea that "the unexamined life is not worth living" (West, 1979, p. 44). These views are important messages about the responsibilities that each individual has to him/herself and to his or her community.

Other thinkers believe that learning can proceed naturally and without much intervention from learned others—that an open environment where children can learn and grow as naturally as possible. A. S. Neill (1960), author of *Summerhill*, would argue that a student will learn what s/he wishes when it becomes important to her or him. Vygotsky (1929) would argue that anything that someone learns must be actively taught. Either way, it may be true that one can only offer strategies and tools for learning, but it is the student who will determine whether or when to use them.

Vygotsky's ideas about how children learn may be compared with the process of cognitive development advocated by Jean Piaget. According to Vygotsky, learning is a social event. Piaget focused on the individual learner as s/he advanced through the four stages of cognitive development. Learning is a natural aspect of what it means to be human, but there are social aspects of cognitive development as the student moves from egocentricity to cognitive independence: "The student becomes independent upon the successful completion of various learning tasks" (Valkenburg & Dzubak, 2009, p.20). One important aspect of Piaget's theories, however, is that a learner "reaches a plateau where s/he processes . . . new information

and begins to develop a new understanding of the world because of it" (Valkenburg & Dzubak, p.21). This concept of learning plateaus lends credence to Neill's idea that a child will learn when s/he is ready. The concept of learning plateaus also supports the idea of scaffolding for adults because as the student learns new information, s/he still has to incorporate that information into a world view or understanding of how ideas may be linked and synthesized.

Piaget's important work may be the middle ground between Vygotsky and Neill. Children and students do seem to move through stages of cognitive development and to process information at various plateaus of their individual learning that integrates (synthesizes) new material with information they already knew. But Neill's point, that the individual should be responsible for his or her own learning when the time is right for him or her, is also relevant and seems to imply that there should be a social or cultural value placed on learning for the sake of learning—not just to get a job or to get along, but to learn because knowledge has value, that learning is the culmination of knowing oneself and examining what is important and meaningful in one's life. At the same time, Vygotsky's concept of the shared responsibility for learning has merit in that teachers, tutors, and facilitators should be responsible for teaching in a manner that will actively engage the student in the learning process. It seems to be a two-way street. Seen as rigid absolutes, Vygotsky's ideas seem stultifying and limited, the cultural imperatives too narrow, but the synthesis that includes the flexibility of the ideas of Piaget and Neill seems to offer a more positive set of options.

The Zone and Scaffolding

According to Vygotsky, every student has the ability to be a learner and a leader in learning situations. He identified two areas of student learning: the Zone of Actual Development (ZAD) and the Zone of Proximal Development (ZPD). The ZAD is defined as the work a student is capable of doing independently—what materials and content the student can manipulate and use without assistance. The ZPD is defined as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers" (Morris, 2008, p. 1). In other words, it is that area where the student needs assistance in order to understand and apply content materials.

Vygotsky's idea is that the potential for cognitive development can be attained when children engage in social learning behavior. Transition through the ZPD depends upon full social interaction. The range of skill that can be developed with adult guidance or peer collaboration exceeds what can be attained alone. In this case, the individual and the social aspects of learning may be achieved when scaffolding is appropriately applied.

Jeffery Wilhelm and his associates, Tanya Baker and Julie Dube (2002), offer an overview of techniques that may be used to effectively apply scaffolding techniques while tutoring or teaching. The process can be described "I do; you watch > I do; you help > You do; I help > You do; I watch."

In other words, the tutor solves a problem while explaining each of the steps in the process. Next, the tutor solves a problem while asking the student to explain certain parts that s/he has come to understand; the tutor supplies correct information when the student has difficulty. The third step has the student solving and explaining the process for solving the problem while the tutor offers suggestions if and when the student needs assistance. The finale is reached when the student can independently solve the problem while the tutor sits by and silently watches. The scaffolding is removed as soon as the student is able to proceed independently. The student goes from learner to possible leader. These same scaffolding techniques can reap tremendous benefits in a small group setting.

Practical Applications

Identifying Need and Demonstrating Practice

Some conventional wisdom about tutoring suggests that characterizing subject matter as hard is a negative approach to gaining student engagement in learning. However, anything that a person finds difficult is hard for him or her, by definition. Denying that is counterproductive. However, the difficulty of subject material does not preclude a successful outcome. As a student gains confidence and skill, it can sometimes be amusing to (intentionally) overstate the level of difficulty of the material. One can imagine a somewhat comical debate between the tutor who claims the material is extremely difficult and the student who argues that it is not so hard after all. One key seems to be the supportive dialogue with the student throughout the entire tutorial process.

One excellent teaching/learning strategy can be seen when one tutor asks another for help on a difficult problem. Here, the collaborative team effort will serve as a model that everyone sometimes needs help and that working with others is often productive. Usually, when tutors get together to solve a difficult problem, they will converse throughout the problem solving process. The exposure of students to this dialogue can be instructive and have a positive impact on their desire to learn because they can see the positive effects of collaboration and communication.

Assessing the Student's Work

One cannot assume that a student approaches his or her studies using appropriate or beneficial learning strategies. Examining the student's work will allow the tutor to suggest those learning strategies that may help the student to learn better, thereby reducing some of the stress the student feels and thus allowing an easier path to learning.

It is helpful to observe the quality of work already done by the student when deciding which approach to use in helping the student. It will help the tutor to determine just where to apply the necessary scaffolding.

While discussing this process of assessing a student's abilities, David Witbrodt, a math and science tutor with over fifteen years experience, commented that he automatically attempts to assess the level of

understanding of any new student he works with and attempts to "jump to the level of that [mathematical or scientific] formula that seems most appropriate" (personal communication, March 14, 2010). It is important to note, however, the revealing comment he made immediately thereafter. "I am often wrong in my first approximation, and have to jump backward or forward in response. Indeed, I sometimes find myself jumping backward and forward during a single tutoring session, as the student's skill level varies with varying material." The process is dynamic and changes according to what the student brings with him or her to the table. The tutor has to be astute and flexible enough to move along with the student.

Earlier, the Socratic Method, the technique of asking a string of directive questions during the dialogue with a student, was mentioned. The dialogue is a way to engage the student in the work and to assess the root of the student's immediate academic support needs. Scaffolding is a worthy technique that can complement or be complemented by Socratic dialogue, and together, they can have a positive impact on student success.

Conclusion

A few years ago, the idea of scaffolding was much more difficult to talk about among members of the tutoring profession. Any discussion of putting one's pencil on the paper or of doing problems for students was strictly forbidden. It is still difficult to get faculty members to understand the concept and see the value of using sample problems. The tutor solves the problem in order to demonstrate the proper method to the student. This serves as the foundational learning platform for students. Scaffolding, when used during tutorial sessions and in small groups, is a powerful tool for helping students to actively engage in their work and in promoting self-sufficiency.

Vygotsky suggested that "What the child can do in cooperation today [,] he can do alone tomorrow" (as cited in Wilhelm, 2002, p. 6). He also suggested that "instruction is good only when it proceeds ahead of development. It then awakens and rouses to life those functions which are in a state of maturing, which lie in the zone of proximal development. It is in this way that instruction plays an extremely important role in development" (as cited in Wilhelm, 2002, p. 6). This instruction can be supported by using scaffolding as an approach to support student learning because it reflects good classroom teaching/learning practice of instructors who show sample problems for new content. If instructors fail to show examples, show inadequate examples, or show perfectly adequate examples that the student is simply unable to comprehend during the class period, then using the scaffolding technique can be of great benefit by providing appropriate examples of problem solving techniques.

Scaffolding, then, is essentially a technique a tutor/facilitator might use to enhance his or her ability to determine the level of independence of the student with regard to a specific set of materials and then to move the student toward the ability to work alone. Not every student will go from failing to an A, but the object of our collective endeavors as tutors and facilitators is to help the student to see that s/he can succeed and to offer a number of suggestions about how the student can solve the problem independently—to become, perhaps, better critical and creative thinkers.

As educators, we, too, need to be critical and creative in our approaches to earning and gaining the trust of the students who come to us. We have to question why and how we do the things we do. We have to reassess the methodologies and technologies we use to teach and understand why we use them. Conventional wisdom, tradition, the way tutoring and teaching has always been done, is not an excuse for ignoring beneficial methods for improving the chances for student learning and success.

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